AASHTO-77
II-1

Products of

NCHRP Projects 8-12 and 8-12A

TRAVEL ESTIMATION PROCEDURES FOR QUICK RESPONSE TO URBAN POLICY ISSUES

by

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A Paper for Presentation at the
63rd Annual Meeting of AASHTO
Atlantic City, New Jersey, November 1977

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Acknowledgment

The work reported herein was sponsored by the American Association of State Highway and Tranpsortation Officials, in cooperation with the Federal Highway Administration, and was conducted in the National Cooperative Highway Research Program which is administered by the Transportation Research Board of the National Research Council.

Disclaimer

This paper is based on an uncorrected draft report as submitted by the research agency. A decision concerning acceptance of the report by the Transportation Research Board and publication in the regular NCHRP series will not be made until a complete technical review has been made and discussed with the researchers. The opinions and conclusiors expressed or implied in the report and in this paper are those of the research agency. They are not necessarily those of the Transportation Research Board, the National Academy of Scences, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, or of the individual states participating in the National Cooperative Highway Research Program.

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ABSTRACT

This paper summarizes research conducted under the National Cooperative Highway Research Program Projects 8-12 and 8-12A, Travel Estimation Procedures for Quick Response to Urban Policy Issues.

The paper reports the findings of research undertaken to identify contemporary transportation policy issues, and to evaluate current travel estimation models and procedures in terms of their abilities to respond to such issues.

Also, a set of manual procedures and transferable parameters are described. These basically correspond to the commonly used four-step transportation planning process. Material is provided in the areas of: trip generation; trip distribution; mode choice; traffic assignment; time of day characteristics; car occupancy factors; capacity analysis; and land development - highway spacing. Numerous tables, charts, nomographs and simplified methods are described. The material developed is organized in a Users Guide. Also included are applications made to three scenarios representing "real" applications.

There are numerous problems where application of the manual methods provided will prove advantageous as compared to the application of computer procedures. The transferable parameters allow quick response as compared to the time required to collect local information.

Two final reports were prepared as a result of this project:

- "Travel Estimation Procedures for Quick Response to Urban Policy Issues" (Final Report);
- "Quick-Response Urban Travel Estimation Manual Techniques and Transferable Parameters" (A Users Guide).

INTRODUCTION

This paper presents the results of a two-phase effort. Phase I included an investigation of policy issues which currently face transportation planning agencies and of the ability of travel estimation procedures to provide information which can respond quickly to urban policy issues. Phase II developed a Users Guide describing transferable parameters and their use with manual and computer techniques for providing quick response travel estimation. Two documents were prepared as NCHRP reports. One, titled, "Travel Estimation Procedures for Quick Response to Urban Policy Issues", provides a reporting of both project phases using the usual NCHRP Research Report format. The second document, "Quick Response Urban Travel Estimation Manual Procedures and Transferable Parameters", was prepared in a users guide format.

In the first phase, policy issues, which face transportation planning agencies were identified by on-site visits to agencies at the state, regional and county levels. Responses to an issue questionnaire were received from many other urban areas of various sizes throughout the United States. In addition, current planning documents and literature were reviewed. Policy issues were compiled and classified and the requirements placed on travel estimating procedures were determined.

Available travel estimation procedures having the ability to provide response were compiled, catalogued, described and evaluated with respect to input, output, applicability and complexity of each of the procedures. A classification

and evaluation system was deveised to allow the potential user to determine which of the available procedures may be appropriate for analysis for a specific purpose. Descriptions and evaluation of 40 models and procedures are in the report, and should prove useful to transportation planners in selecting available techniques appropriate for quick response to policy issues.

No one existing travel estimating technique was found adequate to respond to all of the many questions being asked. Because of the widespread use and understanding of the conventional four-step (trip generation, distribution, modal split and assignment) travel simulation procedure, it was recommended that this procedure continue to form at least a partial basis upon which the transportation planning process responds to new needs in the immediate future.

Phase I concluded that there is a need for a simplified four-step computerized procedure supplemented by "pivot point" * and manual methods. This will reduce time, costs, and manpower requirements, and permit the testing and evaluation of additional land use and transportation alternatives.

In Phase II of the project a Users Guide was developed to describe transferable parameters, factors, manual techniques, etc., to enable the user to carry out a simplified analysis without the necessity of reference to other sources. The Users Guide covers the following elements of transportation planning: trip generation; trip distribution; traffic assignment; capacity analysis; and development density-highway spacing relationships.

*Pivot point techniques predict changes in travel demand from a nominal condition resulting from policy change such as increased user charges.

The Users Guide describes manual methods. However, the tables, graphs and other transferable parameters may be utilized by computer methods as "default" values where more appropriate local information may not be readily available.

Final reports have been provided to the NCHRP for publication, which was recommended by the panel responsible for the projects. The material on manual methods and transferable parameters is expected to receive widespread use. Because of this, three independent reviewers were retained to provide a detailed review of the document to insure accuracy and completeness. Their comments were incorporated in the final report. Currently, plans include conducting training sessions for interested persons through university sponsored seminars.

The two reports prepared for publication are:

- o "Travel Estimation Procedures for Quick Response to Urban Policy Issues"(Final Report);
- o "Quick-Response Urban Travel Estimation Manual Techniques and Transferable Parameters"(A Users Guide).

RESEARCH APPROACH AND SUMMARY RESULTS

The study was conducted in two separately funded phases. Phase I and Phase II were designated Projects 8-12 and 8-12A respectively. Specific objectives, tasks and results for each phase were as follows:

Phase I

The Phase I research effort involved completion of the following objectives:

- Objective A:

  Identification and categorization of contemporary urban policy issues for which travel estimates are required.

- Objective B:

  Evaluation of current and emerging travel estimation models and procedures with respect to their ability to satisfy the requirements of policy issues.

- Objective C:

  Preparations on the basis of Objectives A and B, of a fully supported set of recommendations for the subsequent phase of the project.

In order to identify and categorize as broad a cross-section of policy issues from as many urban areas as possible, various methods were employed. First, a detailed questionnaire on transportation issues was sent to metropolitan planning organizations (MPO's) and Chambers of Commerce in urban areas throughout the country. Second, direct personal interviews were conducted with several transportation officials (planners and operators). Finally,

a thorough review of selected transportation study reports was undertaken.

Table 1 lists transportation policy issues that were identified as requiring quick response analysis. In general, social, economic and land use impacts were cited as primary issues, with the larger urban areas, in particular, showing immediate concern. Issues such as traffic congestion were of primary interest to smaller urban areas. Table 2 indicates the shifts in emphasis within the transportation planning process.

A comprehensive survey was designed to uncover currently available or emerging travel estimation techniques. This survey involved discussions with federal, state and local transportation personnel, plus a nation-wide distribution of an extensive questionnaire to numerous planning agencies, consultants, research organizations and universities. Additionally, a computerized search was undertaken using the Highway Research Information System (HRIS).

The result of the above search yielded a total 40 travel estimation models and procedures. Each of the techniques was intensively reviewed in terms of its mode of operation, the impacts it addressed, its resource requirements, and its effectiveness, merits and limitations. Tables 3 and 4 summarize the manner in which the techniques were evaluated (only four of the forty techniques are shown). The properties of the techniques shown are self-evident.

A merging of the results of Objectives A and B culminated in the recommendations for Phase II of the research effort. The most

TABLE 1

TRANSPORTATION POLICY ISSUES REQUIRING QUICK RESPONSE ANALYSIS

Item	Number of Responding Agencies		
	All Respondents	Metropolitan Planning Agencies	
		Population Over 500,000	Population Under 500,000
Social Impacts	29	14	5
Economic Impacts	26	11	5
Land Use Impacts	26	12	2
Transport Costs	22	7	7
Environment Impacts	20	9	2
Level of Transportation Service	20	7	4
Traffic Congestion	15	4	7

* Entries include multiple responses from several agencies.

TABLE 2

SHIFTS IN EMPHASIS IDENTIFIED WITHIN THE TRANSPORTATION PLANNING PROCESS

FROM	TO
Regional Scale	Sub-Area or Corridor Scales
Highway Emphasis	Transit Emphasis
Coarse Measures	Detailed Measures
Expensive Process	Less Costly Process
Voluminous Output Data	Summaries and Graphics
New Highway Facilities	Improvements to Existing Highway System
Long-Range	Short-Range
New O-D Data	Use of Old Data with Updated Land Use
"Hard" Data on Past Behavior	Use of Attitudinal Data

TABLE 3

MODEL DESCRIPTIONS AND IMPACTS ADDRESSED

Model	Model Description		Impacts			
	Type of Model	Methodology	Economic	Social	Physical	Environmental
1. TRIMS - Transportation Integrated Modeling System	Standard trip generation, distribution, modal split, zone trip alloc, network splice	Standard models chained together, process without intermediate output	Adaptable	Can Deal With	Adaptable	Adaptable
2. SNAP - Stanford Research Institute Network Analysis Program	Similar to FHWA & UTPS packages. "Critical-link" network load. Evaluation.	Operation similar to FHWA & UTPS packages. Performs cost-benefit/ impact analysis	Can Deal With	Can Deal With	Can Deal With	Adaptable
3. DODOTRANS - Decision Oriented Data Organiser Transportation Analysis System	Network cost/ benefit direct demand	Integrated structure of models & files. Uses multi-modal multiple-path, cap.-restrained assignment	Can Deal With	Can Deal With	Adaptable	Adaptable
4. CAPM The Community Aggregate Planning Model	Macro-analytic; produces performance measures for evaluation of alternatives	One-pass package for generation, distribution & evaluation	Can Deal With	Can Deal With	Can Deal With	Can Deal With

TABLE 4

MODEL CHARACTERISTICS AND EVALUATION

Model	Characteristics					Evaluation		
	Time to Obtain Results	Cost	Staff	Data Requirements	Computer Requirements	Effectiveness of Results	Merits	Limitations
1. TRIMS - Transportation Integrated Modeling System	1 month for major changes; overnight for small changes	Machine costs per full run about $100	Planner, analyst; computer personnel not reqd. 1-3 man months for data	Same as for standard UTP models. Input data is streamlined.	IBM 370/158 450.K,6 CPU Min. for 150 Districts.	Accuracy about equal to inter-zone forecasting models	Fast, cheap & simple to use. Requires no knowledge of JCL. Performs both micro & macro assignments	150 Districts, 500 zones, no mode split on non-work trips, no turn volumes, no vine bldng. Limited transit
2. SNAP - Stanford Research Institute Network Analysis Program	1/2-1 day given coded network & familiarity of SNAP	Machine costs per full run about $100	2 man-wks. to learn SNAP. 1 analyst & personnel to code networks	Standard UTP data & other e.g., air and noise pollution	CDC 6400 & at least 5-10 mins. FORTRAN	Good results in 3 applications	Good turnaround. Fully integrated. Extensive evaluation. Output measures for person & goods movement. Field tested.	Max. size 100 zones, 500 nodes, 1000 1-way links. Proprietary; limited documentation
3. DODOTRANS - Decision Oriented Data Organiser Transportation Analysis System	1/2-1 day given coded network & input data	Very expensive to run. But compensated due to single-pass operation	Experienced transportation planners, analysts	Base-year trip, time, cost tables; socio-economic & demographic data	IBM 360/40, 128K, two 2311 disk drives, 2 mins. run time on 370/155 FORTRAN	Number of applications with good results	Integrated model, file structure. Policy responsive. Supply-demand equilibration. "English-Like" commands	Max. size 8191 1-way links. Not yet extensively proven; expensive
4. CAPM - The Community Aggregate Planning Model	1 month for data collection, coding & run. 1 day for testing alternatives	$100 for initial compilation. $50 to test alternatives	1 planner 2 technicians; 1 man-month each	Base & future year data at 8-30 sq. mi. level on community type, system description	IBM 360/65, 190K, 6 CPU mins. for 100 communities. FORTRAN	Several applications - base-year volumes replicated well.	Fast-turnaround. Simplicity of inputs. No network coding. Rapid comparison of alternatives.	No transit analysis. Not widely used yet.

significant of these recommendations was one suggesting the development of manual (non-computerized) travel estimation techniques for transportation planning.

Phase II

The Phase II research effort required meeting the following obectives:

- Objective A:

  Develop a user guide to describe transferable parameters and their use with manual and computer techniques for providing quick response travel estimation.

- Objective B:

  Identify areas of potential high pay-off for development efforts beyond the scope of the current study.

The specific objective was to develop and fully describe for each major element of travel demand analysis, a manual technique, set of factors or appropriate tools to enable the user to carry out a simplified analysis without the necessity of reference to other sources, or without use of the computer. Major estimation components to be investigated included the following:

Trip Generation

Trip Distribution

Mode Choice

Automobile Occupancy

Time of Day Distribution

Trip Assignment

Capacity Analysis

Land Development Density-Highway Spacing Analysis

The work effort was initiated by a thorough state-of-the-art review specifically oriented to manual methods and transferable parameters. Procedures and materials uncovered were evaluated with respect to their data requirements, degree of complexity, types of problems addressable, etc. Further, the procedures were assessed in terms of their appropriateness for inclusion in a users guide format. An identification was made of the inadequacies in the available techniques, and appropriate methods were developed to counter such limitations.

A users guide was developed containing charts, nomographs, formulae, instructions and cautionary statements for the user to actually perform simplified transportation analysis. The manual techniques and transferable parameters provided in the Users Guide are further described in subsequent sections of this paper.

Also contained in the Users Guide is the application of the manual techniques and parameters developed to three scenarios, in addition to several illustrative applications. In general, the results from the scenarios indicate that the manual techniques are capable of yielding answers in time frames often shorter than that for computer applications at a comparable scale. Furthermore, these techniques require minimal input data, and are easy to understand and apply.

Several recommendations were made for future research. Of significance were; one, the development of manual methods to evaluate economic, environmental and land use impacts resulting from transportation policies; two, the provision of generally applicable models and elasticity measures to quickly respond to broad policy issues; and three, further improvement, extension and additional testing of the various techniques already developed. An obvious recommendation was that should further manual methods be developed they ought to be compatible with the non-computerized techniques already produced during this project.

NEED FOR MANUAL METHODS AND TRANSFERABLE PARAMETERS

Computer application to transportation planning has developed to the current extent due to the requirement of handling large amounts of data. Large amounts of data are used because of the complexities of the procedures developed and the extent of area to be evaluated. Simplified procedures are required for quick response to policy issues which do not require the application of large scale computer models when an element of a plan is to be changed or various levels of service are to be tested in some portion of a region.

Manual procedures are desirable for determining supply and/or demand for transportation facilities for policy evaluation purposes. These procedures will be most appropriate for sub-areas or specific sites and corridors. For highway facilities, the procedures would be able to estimate needed capacity and subsequent impacts of new development (i.e., a shopping center). For transit, usage and costs for route extensions should be developable. Many procedures for accomplishing this are described in the Users Guide along with useful parameters.

The manual techniques were developed in such a manner that each could be applied independently of the others, yet the techniques could be combined to operate interdependently. Except for the typical demographic and socio-economic input data, such as population and household income, and general system description, the user can operate these procedures without reference to other sources and at that, with nothing more sophisticated than a hand-held electronic calculator.

It is intended that a transportation planner or analyst with a 2-3 year level of experience can apply the techniques contained in the Users Guide. It is possible to train a technician to use portions, or all of the methods.

The manual methods are manageable in application and it is possible to produce reasonably accurate results quite rapidly for many applications. To exemplify, the transit demand potential on a single route was estimated in a few hours; spacing requirements based upon alternate land development policies was determined within 2-3 days. Further, the transportation impacts of a major residential site were calculated within a week, and a proposed improvement in a corridor was evaluated in about the same time. These findings confirm the quick response capabilities of the manual procedures developed.

In order to fully realize the potential of the manual techniques, it is necessary that the user/planner modify conventional ideas about the planning processes. First, it must be understood that since the manual methods provided are quick and simple, clerical and technical help can be substituted for the computer and computer specialist. Therefore, manual analysis can be very cost-effective. Second, it is anticipated that in most cases, the user of such methods would acquire a deeper understanding and be better able to work with the four-step elements, than if all comparable work was done by computer. Consequently, his ability to clearly present the process and results to elected officials and the public

would be enhanced. The manual methods are not offered as a replacement to the computer models, but rather as auxiliary or alternate methods for quicker and sometimes rougher estimates.

When calibrating and applying travel estimation models, locally collected data provides the anlayst material that might enhance the results of any study. The availability of such data, however, depends very often on expensive and time consuming data collection procedures. In consequence, the ability to quickly respond to policy issues is negated. Recent transportation research has revealed that for a broad range of analysis, certain parameters, factors and relationships from one study area, can quite satisfactorily suffice when transferred to another area having similar characteristics.

As part of this project a large array of transportation data was compiled for use as "default" values. Where more pertinent local information is not available, or where collection of new data is not warranted, these transferable values could be quite useful in both manual and computer applications. This material, supplied in the Users Guide, is in the form of tables, charts, nomographs and formulae. In the development of such information, data consistency was maintained throughout. That is, wherever possible and appropriate, the parameters have been grouped together and reported for four urbanized area population groups, three trip purposes and two modes as follows:

Urbanized Area Population:

1. 50,000 - 100,000 population
2. 100,000 - 250,000 population
3. 250,000 - 750,000 population
4. 750,000-2,000,000 population

Trip Purposes:

1. Home-based work trips (HBW)
2. Home-based non-work trips (HBNW)
3. Non-home - based trips (NHB)

Modes:

1. Highway
2. Transit

MANUAL METHODS AND TRANSFERABLE PARAMETERS PROVIDED

The manual techniques and transferable parameters developed are documented in a Users Guide titled, Quick-Response Urban Travel Estimation Manual Techniques and Transferable Parameters. The following sections highlight the capabilities of the major travel estimation components of the transportation planning process contained in the Users Guide.

A selected number of important graphs and tables used as part of the estimation techniques are exhibited, but in the interest of brevity, only for the 100,000 - 250,000 urbanized area population.

TRANSFERABLE PARAMETERS

The Users Guide contains many tables and graphs of transportation related information. The information in these has been obtained from various sources, most significantly urban transportation planning studies undertaken over the past twenty years. Previous research efforts also provided a rich source of pertinent information.

The transferable parameters should be considered as "default" values to be utilized when no corresponding information is available locally, where time of response does not permit data gathering or where the cost of gathering additional data does not appear warranted. The transferable parameters may be used with computer models or may be used with the manual methods provided.

The transferable parameters provided may be summarized as shown below:

Trip Generation

- Vehicle trip rates for many types of generators - see Table 5
- Detailed person trip rates by income and/or auto ownership - see Table 6
- Generalized trip production and attraction parameters including mode split, purpose, truck trips and external trips - see Table 7

Trip Distribution

- Speed table values by facility and urbanized area
- Impedance values for gravity model application
- Airline distance converted to travel time and distribution factor (F factor) - see Figure 1
- Trip distributions for several types of site

Mode Choice

- Auto and transit impedance calculation curves - see Figure 2
- Rule of thumb elasticity measures

Auto Occupancy

- Occupancy by trip purpose - see Table 8
- Occupancy adjustments for time-of-day
- Occupancy adjustments by trip length
- Auto occupancy by income and parking cost
- Auto occupancy by land use

TABLE 5

AVERAGE VEHICLE TRIP RATES AND OTHER CHARACTERISTICS OF GENERATORS

GENERATOR[b]	VEHICLE TRIPS[c] TO & FROM PER DAY PER		PERCENT IN HOUR SHOWN			TYPICAL AUTO OCCUPANCY	TYPICAL % TRANSIT OF TOTAL PERSON TRIPS[d]
	DWELLING UNIT	ACRE	AM PEAK	PM PEAK	PEAK HR OF GEN.		
Residential Single Family							
1 Du/acre	9.3	9.3	8.0	10.8	10.8	1.62	3.2
2 Du/acre	9.3	18.6	8.0	10.8	10.8	1.62	3.2
3 Du/acre	10.2	30.6	8.0	10.8	10.8	1.67	3.2
4 Du/acre	10.2	40.8	8.0	10.8	10.8	1.67	3.2
5 Du/acre	9.1	45.5	8.0	10.8	10.8	1.62	3.2
Medium Density (Duplex, Townhouses etc.)							
5 Du/acre	7.0	35.0	8.0	10.8	10.8	1.57	5.6
10 Du/acre	7.0	70.0	8.0	10.8	10.8	1.57	5.6
15 Du/acre	7.0	85.0	8.0	10.8	10.8	1.57	5.6
Apartments							
15 Du/acre	6.0	90.0	7.9	10.8	10.8	1.56	12.4
25 Du/acre	6.0	150.0	7.9	10.8	10.8	1.56	12.4
35 Du/acre	6.0	210.0	7.9	10.8	10.8	1.56	12.4
50 Du/acre	6.0	300.0	7.9	10.8	10.8	1.56	12.4
60 Du/acre	6.0	360.0	7.9	10.8	10.8	1.56	12.4
Mobile Home Park							
5 Du/acre	5.5	27.5	8.3	10.8	12.5	1.54	1.0
10 Du/acre	5.5	55.0	8.3	10.8	12.5	1.54	1.0
15 Du/acre	5.5	82.5	8.3	10.8	12.5	1.54	1.0
Retirement Community							
10 Du/acre	3.5	35.0	12.1	12.1	12.1	1.48	6.0
15 Du/acre	3.5	52.5	12.1	12.1	12.1	1.48	6.0
20 Du/acre	3.5	70.0	12.1	12.1	12.1	1.48	6.0
Condominiums							
10 Du/acre	5.9	59.0	7.1	7.1	7.1	1.56	9.0
20 Du/acre	5.9	118.0	7.1	7.1	7.1	1.56	9.0
30 Du/acre	5.9	177.0	7.1	7.1	7.1	1.56	9.0
Planned Unit Develop.							
5 Du/acre	7.9	39.5	10.1	10.1	10.1	1.58	7.1
15 Du/acre	7.9	118.5	10.1	10.1	10.1	1.58	7.1
25 Du/acre	7.9	197.5	10.1	10.1	10.1	1.58	7.1

TABLE 6

DETAILED TRIP GENERATION CHARACTERISTICS[a]
URBANIZED AREA POPULATION: 100,000-250,000

Income Range 1970 $ (000's)	Avg Autos Per HH[d]	Average Daily Person Trips Per HH[e]	% HH by Autos Owned[b]				Average Daily Person Trips Per HH by No. of Autos/HH[c]				% Average Daily Person Trips by Purpose[f]		
			0	1	2	3+	0	1	2	3+	HBW	HBNW	NHB
0-3	0.49	4.0	57	37	6	0	1.0	7.5	10.5	13.8	20	63	17
3-4	0.72	6.8	36	56	8	0	1.7	9.2	13.3	16.4	22	60	18
4-5	0.81	8.4	29	61	10	0	2.5	10.2	14.5	17.6	22	58	20
5-6	0.94	10.2	21	65	13	1	3.5	11.4	14.5	19.0	22	58	20
6-7	1.01	11.7	17	66	16	1	4.5	12.5	15.6	20.5	20	58	22
7-8	1.14	13.6	12	65	21	2	5.4	13.8	17.0	22.2	20	57	23
8-9	1.25	15.3	9	61	28	2	5.8	15.0	17.5	23.0	20	57	23
9-10	1.34	16.2	6	58	33	3	6.3	15.8	18.0	23.5	19	57	24
10-12.5	1.50	17.3	4	50	40	6	6.8	16.0	19.0	24.5	19	57	24
12.5-15	1.65	18.7	2	40	51	7	7.0	16.0	20.4	25.0	19	56	25
15-20	1.85	19.6	2	28	57	13	7.2	15.0	21.0	25.5	18	56	26
20-25	2.01	20.4	1	20	61	18	7.5	15.0	21.0	25.5	18	55	27
25+	2.07	20.6	1	19	59	21	7.5	15.0	21.0	25.2	18	55	27
Wt. Avg.	1.55	14.5	14	48	33	6	5.4	13.7	18.4	22.4	20	57	23

FOOTNOTES:

a. Total of internal and external trips generated by area residents.
b. Source: 1970 Census
c. Source: Origin-Destination Surveys
d. Calculated (using b)
e. Calculated (using b and c)
f. Source: References (16 and 18)

TABLE 7

TRIP GENERATION PARAMETERS

PART A - TRIP PRODUCTION ESTIMATES
(Total Internal Plus External Trips made by Internal Residents)

Urbanized Area Population	Average Daily Person Trips Per HH[a]	% Average Daily Person Trips by Mode[b]			% Average Daily Person Trips by Purpose[a]			Auto Person Trips as a % of Total Person Trips[c]			Auto Driver Trips as a % of Total Person Trips[d]		
		Public Transit	Auto Passenger	Auto Driver	HBW	HBNW	NHB	HBW	HBNW	NHB	HBW	HBNW	NHB
50,000- 100,000	14	2	40	58	16	61	23	96	99	98	75	52	64
100,000- 250,000	14	6	30	64	20	57	23	88	97	94	80	58	70
250,000- 750,000	12	8	31	61	20	55	25	84	96	92	74	56	66
750,000-2,000,000	8	13	30	57	25	54	21	74	93	86	64	54	61

FOOTNOTES:

a. From Table 2
b. Source: Reference (18)
c. Source: Origin-Destination Surveys
d. Calculated using c and auto occupancy measures from Table 8.

TABLE 7 (continued)

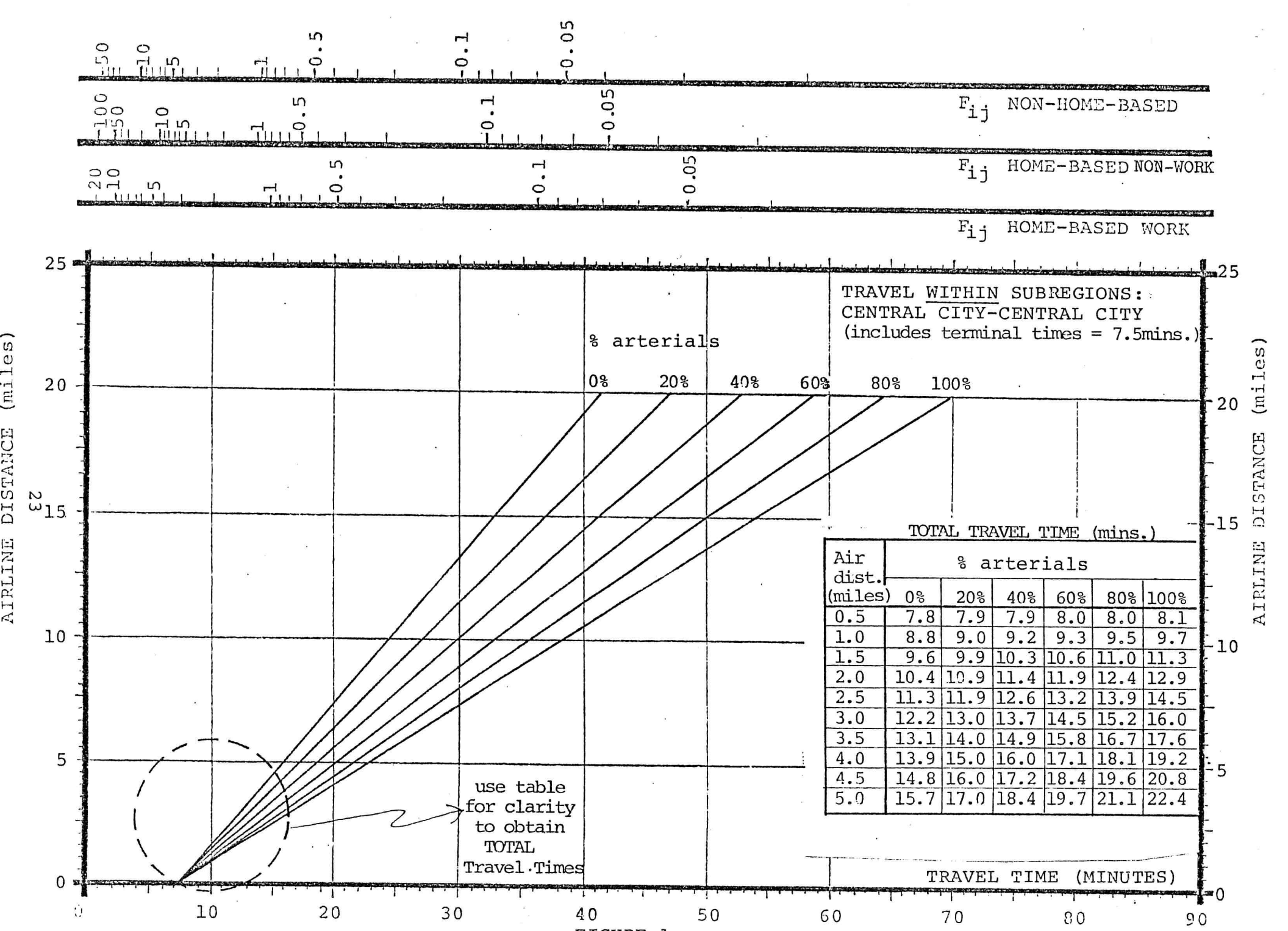
TRIP GENERATION PARAMETERS

PART B - USEFUL CHARACTERISTICS FOR TRIP ESTIMATION
(Vehicle Trips made by Internal Residents)

Urbanized Area Population	External Travel Characteristics		Total Areawide Truck Trips as a % of Areawide Auto Driver Trips[b]
	% of Total External Vehicle Trips Passing Through Area[a]	% of Total External Vehicle Trips to he CBD[a]	
50,000- 100,000	21	22	27
100,000- 250,000	15	22	17
250,000- 750,000	10	18	16
750,000-2,000,000	4	12	16

FOOTNOTES:

a. Source: Reference (19)
b. Source: Reference (18)



TOTAL TRAVEL TIME (mins.)

Air dist. (miles)	% arterials					
	0%	20%	40%	60%	80%	100%
0.5	7.8	7.9	7.9	8.0	8.0	8.1
1.0	8.8	9.0	9.2	9.3	9.5	9.7
1.5	9.6	9.9	10.3	10.6	11.0	11.3
2.0	10.4	10.9	11.4	11.9	12.4	12.9
2.5	11.3	11.9	12.6	13.2	13.9	14.5
3.0	12.2	13.0	13.7	14.5	15.2	16.0
3.5	13.1	14.0	14.9	15.8	16.7	17.6
4.0	13.9	15.0	16.0	17.1	18.1	19.2
4.5	14.8	16.0	17.2	18.4	19.6	20.8
5.0	15.7	17.0	18.4	19.7	21.1	22.4

FIGURE 1

AIRLINE DISTANCE vs. TRAVEL TIME vs. DISTRIBUTION FACTORS BY TRIP PURPOSE:
URBANIZED AREA POPULATION = 100,000 - 250,000

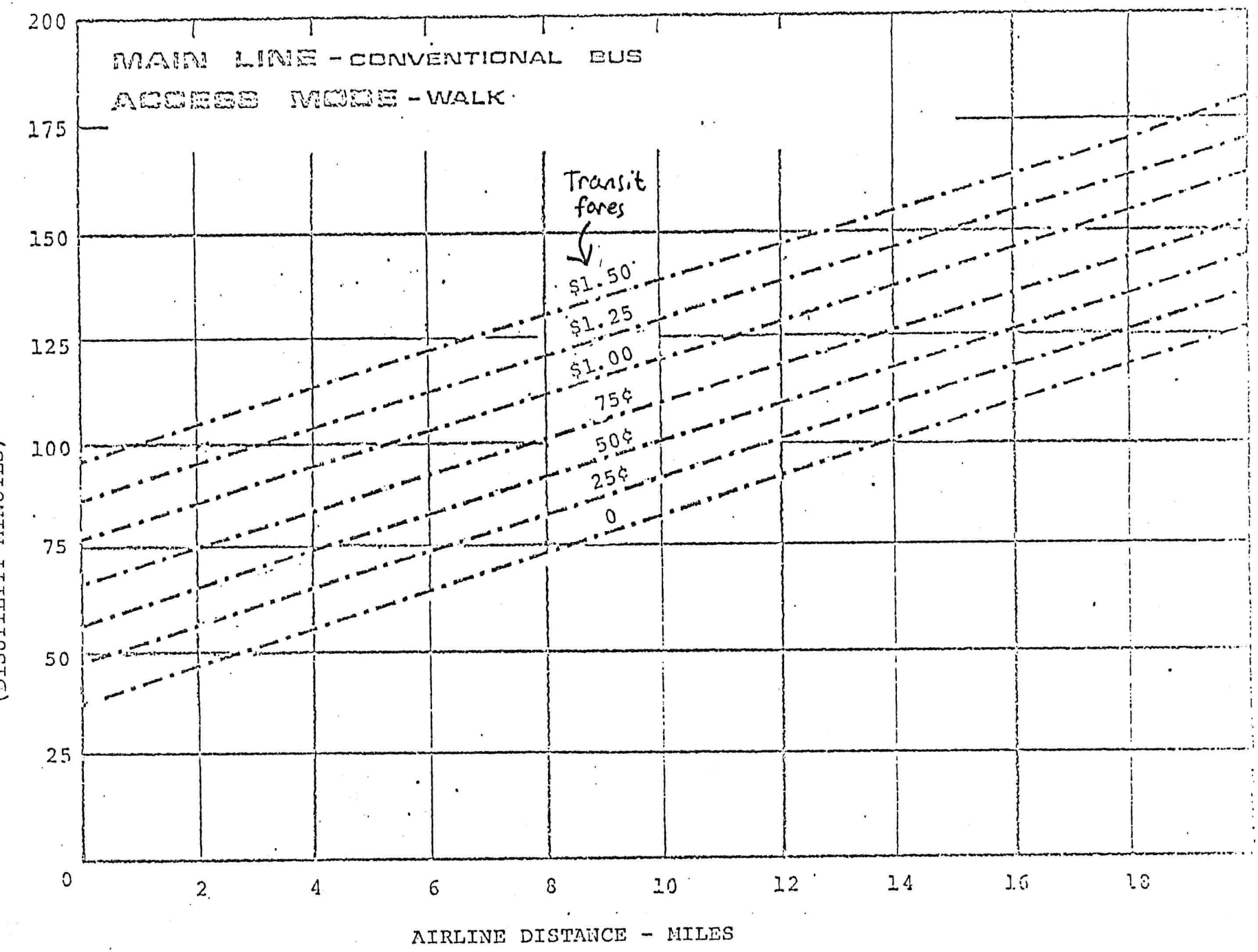


FIGURE 2

GRAPH FOR AIRLINE DISTANCE CONVERSION TO TOTAL TRANSIT IMPEDANCE

TABLE 8

AVERAGE AUTO OCCUPANCY

RATES (1976) BY

URBANIZED SIZE AND TRIP PURPOSE

URBANIZED POPULATION AREA	TRIP PURPOSE						
	HB WORK	HB SHOP	HB SOC-REC	OTHER HB	HB OTHER*	NHB	TOTAL
50,000 - 100,000	1.38	1.57	2.31	1.52	1.82	1.43	1.50
100,000 - 250,000	1.37	1.57	2.31	1.52	1.81	1.43	1.50
250,000 - 750,000	1.35	1.57	2.30	1.52	1.77	1.43	1.50
750,000-2,000,000	1.33	1.58	2.29	1.51	1.74	1.43	1.51

* This is an average of HB Shop, HB SOC-REC and Other HB. It is to be used where trips have been grouped into 3 categories: HB Work; HB Other; NHB.

Time-of-Day Distributions

- Hourly distributions of internal auto driver trips by purpose
- Hourly distributions of internal auto driver and total vehicles
- Hourly distributions of total travel on freeways/expressways
- Hourly distributions of travel on arterials - see Table 9
- Hourly distributions of travel on collectors
- Transit patronage time period distribution factors - see Table 10
- Conversion factors for person trip tables - see Table 11

MANUAL PROCEDURES

A set of manual procedures has been developed which roughly parallels the four-step transportation planning elements of trip generation, trip distribution, mode choice and traffic assignment. The manual elements are similar to techniques used by most transportation planners. However, several improvements are included such as elimination of calibration through use of parameters provided, reduction of effort in route selection, simplification in calculation and provision of simplified work sheets. Manual procedures are provided in the areas of trip distribution, traffic assignment, mode choice, capacity analysis and land development-facility spacing relationships. Alternate methodologies are provided for elements where different levels of analysis may be appropriate based upon considerations such as time and available information.

TAB 9

HOURLY DISTRIBUTION OF TOTAL TRAVEL ON ARTERIALS
(URBANIZED AREA = 100.000 - 250.000 POPULATION)

HOUR	AREA TYPE										HOUR
	CBD		Central City				Suburb				
	All Orientations		Radial		X-Town		Radial		X-Town		
	% ADT	DIR SPLT*	% ADT	SPLT*	% ADT	SPLT*	% ADT	SPLT*	% ADT	SPLT*	
24-1	1.0	38	1.0	40	1.0	44	1.0	50	1.0	44	24
1-2	0.5	40	0.5	44	0.5	44	0.5	50	0.5	50	1
2-3	0.5	34	0.5	42	0.5	46	0.5	50	0.5	42	2
3-4	0.5	42	0.5	48	0.5	48	0.0	50	0.5	52	3
4-5	0.5	54	0.5	52	0.5	54	0.5	50	0.5	48	4
5-6	1.0	66	1.0	64	1.0	54	1.0	62	1.0	66	5
6-7	4.0	78	3.0	70	3.0	58	2.5	66	2.5	66	6
7-8	8.0	70	7.0	68	7.5	56	7.0	74	7.5	68	7
8-9	7.0	58	5.5	58	5.5	56	6.0	66	6.0	52	8
9-10	6.0	52	5.0	52	5.0	54	5.0	56	4.5	50	9
10-11	6.0	52	5.0	50	5.5	54	5.0	54	4.5	48	10
11-12	6.5	50	5.5	48	5.5	50	5.5	50	5.5	48	11
12-13	6.5	50	6.0	50	6.0	50	6.0	48	5.5	52	12
13-14	6.5	52	6.0	50	5.5	50	6.0	50	5.5	50	13
14-15	5.5	38	6.5	52	6.5	50	6.0	50	5.5	50	14
15-16	6.0	34	7.5	48	7.5	46	7.0	48	6.5	50	15
16-17	8.0	46	8.5	42	8.0	46	8.0	42	7.5	46	16
17-18	7.5	46	8.0	38	7.5	46	8.5	36	9.0	36	17
18-19	4.5	48	5.5	44	6.0	50	6.5	42	6.5	42	18
19-20	4.0	48	5.0	48	5.0	48	5.5	48	5.5	44	19
20-21	3.5	46	4.0	48	4.0	48	4.0	48	5.0	46	20
21-22	3.0	52	3.5	54	3.5	46	3.5	44	4.0	50	21
22-23	2.0	56	2.5	46	2.5	48	2.5	48	3.0	48	22
23-24	1.5	40	2.0	48	2.0	48	2.0	50	2.0	46	23
	100.0		100.0		100.0		100.0		100.0		

* % in AM peak direction

TABLE 10

CONVERSION FACTORS FOR CRITICAL
TIME PERIODS OF TRANSIT TRIPS

HAVE ↓ / NEED →	ANNUAL AVERAGE WEEKDAY VOLUME	COMBINED PEAK PER. (4 HOUR) VOLUMES	PEAK HOUR VOLUMES	PEAK HOUR PEAK DIRECTION
ANNUAL AVERAGE WEEKDAY VOLUMES		0.50	0.17	0.14
COMBINED PK. PER. (4 HOUR) VOLUMES	2.00		0.34	0.28
PEAK HOUR VOLUMES	5.88	2.94		0.82
PEAK HOUR PEAK DIRECTION	7.14	3.57	1.21	

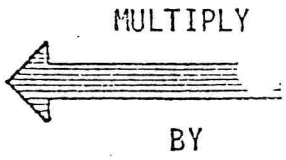


TABLE 11

CONVERSION FACTORS FOR
CRITICAL PERIODS OF INTERNAL PERSON TRAVEL
URBANIZED AREA: 100,000 - 250,000 POPULATION

HAVE \ NEED	Total Travel	Total Work Travel	Comb. Pk.Pd. Total Travel	Pk.Hr. Total Travel	Comb. Pk.Pd. Work Travel	A.M. Pk.Pd. Work Travel	P.M. Pk.Pd. Work Travel	Pk.Hr. Work Travel
Total Travel		0.181	0.288	0.095	0.105	0.058	0.049	0.036
Total Work Travel	5.515		1.586	0.528	0.579	0.321	0.273	0.199
Comb. Pk.Pd. Total Travel	3.477	0.630		0.332	0.365	0.203	0.172	0.126
Pk.Hr. Total Travel	10.449	1.894	3.006		1.097	0.608	0.517	0.378
Comb. Pk.Pd. Work Travel	9.508	1.727	2.740	0.912		0.555	0.471	0.344
A.M. Pk.Pd. Work Travel	17.171	3.113	4.939	1.644	1.803		0.850	0.621
P.M. Pk.Pd. Work Travel	20.209	3.644	5.812	1.934	2.122	1.177		0.730
Pk.Hr. Work Travel	27.670	5.017	7.959	2.648	2.905	1.612	1.369	

Trip Distribution

The gravity model formulation was used to provide a manual trip distribution method. A number of models, short cut techniques and sources for model calibration factors were investigated. Of the models investigated, the gravity type formulation was viewed as the most transferable based upon the number of applications made and the ability to package distribution factors (F-values).

A set of graphs is provided which obtains the distribution factor from measurement of straight line distance between points and a gross estimate of the proportion of freeway use (see Figure 1). Other computational simplifications are provided which allow application for up to about 80 analysis areas. Some timing estimates made indicate that for a single purpose approximately 30 manhours are required to calculate interchanges between 30 analysis areas and about 85 hours for 80 areas. Other simplifications are provided for site and corridor analysis and for the use of accessibility indices when available from other sources such as a regional model.

Useful material developed and provided in the Users Guide for the trip distribution phase consisted of the following:

- Nomograghs for the development of zone-to-zone travel time/friction factor matrices - for the four urbanized area population groups;
- Gravity model travel time exponents - for four population groups and five trip purposes;
- A method for distributing trips around a site by reversing productions and attractions;

- The use of accessibility indices (once computed from a manual Gravity Model application) for quick determination of inter-zonal trip interchanges;
- Trip distribution patterns for selected sites.

The use of the travel time/friction factor nomographs warrants some discussion. Essentially, the travel times can be derived by first, measuring the zone centroid-to-centroid airline distance off a map; then estimating the proportion of travel on arterials or freeways; next, determining the distances traveled in each subregion (i.e., CBD or central city or suburbs); and last, entering the nomographs such as those illustrated in Figure 1. Appropriate nomograhs must be selected depending on whether the travel is totally within a subregion, or whether it is across two or three subregions. The nomographs also provide the origin-destination terminal times which after adding to the in-vehicle time, the user can develop friction factors for each of the three trip purposes (HBW, HBO, NHB). The Users Guide provides instructions for the planner to allow construction of these nomographs to suit his local conditions, if so desired.

Mode Choice Estimation

It was desired to provide capabilities for mode allocation between points in an area (i.e., as along a route) and a simply applied method. Also, the ability to determine sensitivity/elasticity type results from the method would be useful.

The method selected for mode choice estimation is based upon the UMTA Default Model contained in program UMODEL of the UTPS package and as expanded in "A Manual Technique for Preliminary

Transit Corridor Analysis".

The mode choice equation for any ij pair is:

$$MS_t = \frac{T_a^b}{T_a^b + T_b^b}$$

where:

MS_t = Market share of transit

T_a = Auto impedance

T_b = Transit impedance

b = Exponent of time (similar to gravity model time values)

The approach allows the user to determine a market share for any O-D pair. With basic input information such as airline distance, transit fare, parking cost and operating speed, the user will be able to look up a transit or auto impedance using curves like those shown in Figure 2. Exponent values (b) are provided for different area sizes and trip purposes allowing development of curves more appropriate to a specific area. From the impedance values, the user can enter a nomograph such as shown in Figure 3, and read directly the market share for each of the auto and transit modes.

Also included are techniques to allow the user to test policy options, such as increased fares or increased parking costs, and determine the market elasticity.

Traffic Assignment

The techniques investigated can be categorized into 4 groups:

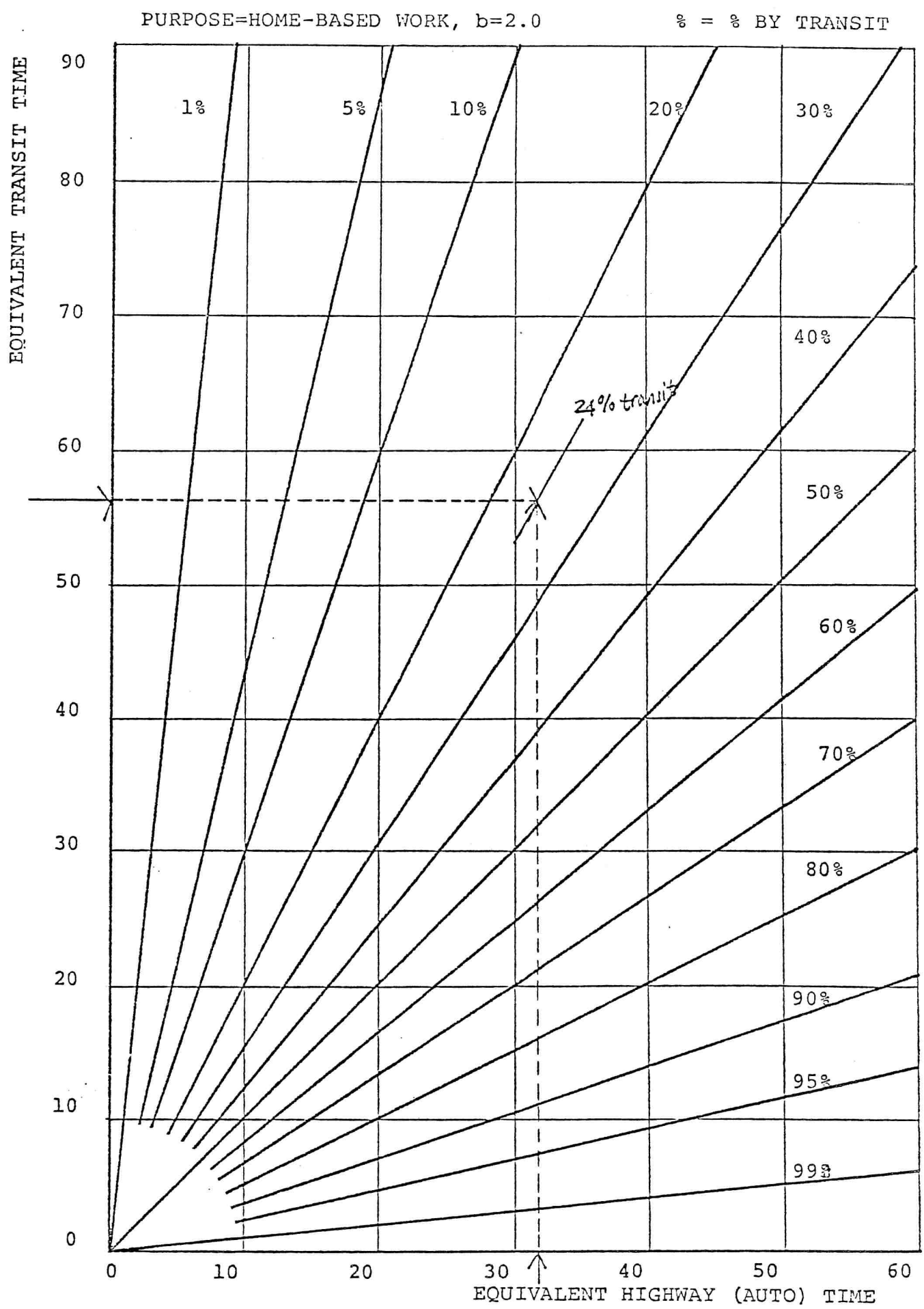


FIGURE 3

MODE CHOICE MODEL NOMOGRAPH: HOME-BASED WORK

1. Traditional traffic assignment
2. Traffic generation and decay
3. Traffic growth factors
4. Traffic diversion/traffic shift

The above classifications have varying application based on the particular problem under consideration.

Traditional traffic assignment is generally useful for evaluation of an entire transportation system or portion thereof and an associated land use and population configuration.

Traffic generation and decay is useful for evaluating the effect of addition of a new traffic generator (shopping center, airport, etc.) on an existing highway system. An estimate is made of the quantity of traffic a new generator will produce. This traffic is added to the existing base traffic and the facilities are evaluated as to their ability to handle the new development.

Traffic growth factors can be applied to given system volumes to produce a measure of future volumes. The growth factors are usually a function of population and employment growth. This procedure has possible applications in the study of corridor growth.

Traffic diversion/traffic shift is a technique for assessing the impact of additional highway facilities to an existing system.

Three procedures are described for manual traffic assignment in the Users Guide. The first is a manual approach to stringing trips through a network and simplified bookkeeping of the resultant trip volumes (i.e., traditional traffic assignment). This is described at two levels: detail assignments around a specific site including resultant facility volumes and turning movements; less

detailed assignments to highway facilities at a corridor level or "sketch" planning regional level. The second procedure is a variation of the methods developed by Gruen Associates for arterial spacing in suburban areas. The basic concept provides a series of charts that can be used to determine traffic estimates based on residential density. These estimates can be further refined using nomographs for: density and project size; level of traffic service; car ownership transit usage; non-residential activity mix and freeway diversion.

A sketch planning process is included in the Users Guide for estimating probable shifts in volume between competing facilities in a corridor. This is based upon the process used by Dial in his stochastic assignment process but is not based on use of an O-D table or route determination. Rather, a diversion factor is developed based upon known volumes and operating speeds. This function is used to estimate shifts between facilities based upon improvements in operation.

Capacity Analysis

The techniques described for manual application are basically applicable corridor/subarea problems or intersection problems related to a site anlaysis.

For intersection capacity analysis for planning applications, the Critical Movement Summation technique has been utilized. The technique, which has been used by several planning agencies, is based upon the calculation of a critical intersection volume and a

comparison of this volume with a benchmark intersection capacity stratified by level of service.

The corridor analysis described consists of cutline evaluations within a corridor and the subsequent preparation of a facilities stress diagram. Tables and nomographs are provided for simplified estimates of capacities at the proper level of detail for planning applications.

Development Density-Highway Spacing Relationships

The basic purpose of developing relationships between land use and highway spacing is to permit the rapid development of a "first-cut" estimate of future highway needs based on a desired level of highway service. Given a distribution within an area of land use, either in terms of activities (people, households, jobs) or acres by type of use, and given the presence of an existing highway system, the average trip length is computed. This average trip length is then adjusted for the future. Future vehicle trip ends are computed, adjusted for transit service and VMT's computed.

Volumes for the existing spacings of freeways and arterials are then determined and compared with desired volumes. With desired volumes known, desirable spacings are determined. Comparisons of desired and existing spacings give a measure of need for the area.

A variation of the approach is to run the procedure backwards, solve for desired volumes, and given existing spacing, divide by

the trip length to determine the amount of trip generation and land use which can still be accommodated by the highway system. Tables of highway spacing, lane-miles, level of service and dwelling unit or equivalent non-residential densities are provided.

TEST CASE APPLICATIONS OF THE MANUAL ESTIMATION TECHNIQUES

To determine the capabilities of the manual methods and transferable parameters described in the Users Guide, extensive applications were made to three different types of transportation scenarios. Each of these scenarios was based on field conditions and data input obtained from three study areas, namely, Boise, ID., Columbus, OH., and Fairfax County, VA.

The Boise Application

In Boise, because of its rapid growth, numerous studies are made to analyze and evaluate transportation impacts of proposed new development. As such, the Boise scenario was based on the investigation (for the year 2000) of traffic impacts on the surrounding highway system, of a proposed residential development and a large shopping center. Almost all of the manual techniques contained in the Users Guide were put to use to quantify these effects. The entire investigation - trip generation through assignment and capacity analysis - required a total of 60 man-hours. It was estimated that if only HBW trips were developed and then expanded to total trips (using factors such as those contained in Table 14), the work effort would have been reduced to about 40 man-hours.

The Columbus Application

In Columbus, a current transportation problem was the evaluation of a proposed improvement for a corridor - i.e., to widen a two-lane highway to four lanes. The facility is on the outskirts

of the city and as such, is not within the area for which regional planning is presently accomplished, a typical issue in a number of medium sized areas. The objective of the Columbus scenario, then, was to determine for the year 2000, the impacts of the proposed corridor development and the concurrent growth. Again, most of the manual estimation techniques described were used for the corridor impact analysis. The scenario was conducted in about 66 man-hours.

The Fairfax Application

Fairfax County is a growing suburban county in the Washington, D.C. metropolitan area, with varying degrees of development densities. Currently, there is a large amount of commuting to the Washington downtown area, and rail rapid transit and a major freeway have been proposed to serve the county. The scenario selected for analysis was to determine the base year and future year (1985) levels of service provided by the current and planned transportation systems in the county. Inputs required were a measure of future land activity and of the transportation system. The manual techniques described in the Users Guide were used to estimate the present and future travel, to allocate this travel by sub-area to freeway and arterial facilities and, then to compute the resulting levels of service. The scenario required approximantely 22 man-hours.

APPLICATION OF MANUAL METHODS AND TRANSFERABLE PARAMETERS

The parameters and manual methods provided in the Users Guide are based upon the four-step transportation planning approach familiar to most transportation planners. This familiarity should result in a relatively short learning process.

The manual methods are most appropriate for:

- Traffic impact analysis of new development
- Evaluation for corridor improvements
- Assessment of transit service improvements in specific areas
- System spacing requirement determination based upon alternate development patterns
- Assessment of very broad assumptions regarding development shifts and facility location.

The parameters and manual methods have been successfully applied to a site impact analysis, a corridor analysis and a spacing problem in scenarios developed as previously discussed. Timing logs kept during these applications indicate that the application of these manual methods is quite feasible.

The parameters provided should prove useful in many applications. They can be used in both manual and computer applications where more pertinent local information is not available or collection of new data is not warranted.

The information provided on trip generation will be useful to urban planning agencies, State Departments of Transportation and developers to assist in assessing the impact of sites on the transportation system. The information will be useful in assessing changes

in travel based upon changes in population and socio-economic factors.

The material on trip distribution should simplify much analysis and computer work in assessing changes in land use patterns and making better use of the output of computer analyses such as accessibility indices.

The mode choice estimation process provides a simplified means for assessing the need for transit service along particular routes as well as quickly assessing changes in service, fares, parking costs, travel time, etc.

The traffic assignment methods described allow manual traffic assignment using traditional "stringing" methods to assist in determining specific facility traffic loads. The methods also allow turning movement estimation in small analysis areas. A simplified process for estimating the street requirements in a new development as well as the external requirements caused by the development is provided to assist in evaluating improvements in facilities in a corridor. A manual sketch diversion process is provided. A capacity analysis process is provided for corridors as well as intersections.

Traffic agencies may find considerable use in the application of hourly and directional factors provided for particular trip purposes as well as facility types. These data will be useful in converting total daily estimates to operational and design volumes.

Car occupancy factors should prove useful to planning agencies to assess parking requirements for particular generators as well as possible changes based on income and parking charges.

The development density/spacing relationships will prove useful to urban planning agencies, where portions of the region are growing quickly and assessment of street requirements must be made. Likewise, evaluation of the development which can be supported by the current system can be evaluated.

The material describing 40 models and procedures should prove useful to urban area planners and State planning personnel to assess capabilities available for specific problem applications and their ability to satisfy the requirements of policy issues. The material described is basically concerned with methods which provide transportation related output with the minimum of input resource requirements in a short elapsed time as compared to standard urban transportation planning computer packages. A summary of each model and procedure is provided including evaluation criteria such as time to obtain results, costs for application, effectiveness of results, staff requirements, computer requirements, scale of application, etc. A set of evaluation and classification tables is provided to assist in determination of an appropriate model or procedure for a particular appplication.

In summary, the material provided has been shown to be appropriate for several types of applications. It is expected that through use by State and local personnel and the gaining of familiarity with manual methods a larger number of uses will emerge.

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